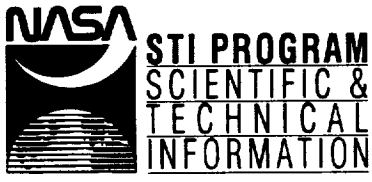
NASA Technical Memorandum 109924

NASA Access Mechanism— Lessons Learned Document

Judy Hunter
Denise Duncan
Curtis Generous
Lisa Burdick
Rick Dunbar
John Lycas
Ardeth Taber-Dudas
National Aeronautics and Space Administration
Washington, DC

July 1994



This publication was prepared by the NASA Center for AeroSpace Information,
800 Elkridge Landing Road, Linthicum Heights, MD 21090-2934, (301) 621-0390.

Table of Contents

CHAPTER ONE - Background
- I.A. WHY A GATEWAY PROTOTYPE? 1
- I.B. PROJECT HISTORY 1
  - I.B.1. NASA STI Program Overview 1
  - I.B.2. User Requirements 2
  - I.B.3. Conceptual Design 4

CHAPTER TWO - Prototype
- II.A. SYSTEM DESIGN CONSIDERATIONS 7
  - II.A.1. Hardware Factors 7
  - II.A.2. Operating System Factors 8
  - II.A.3. Graphical Interface Factors 8
  - II.A.4. Development Tools Factors 9
  - II.A.5. XWindow Development Toolkit Considerations 10
  - II.A.6. Networking Considerations 10
  - II.A.7. Z39.50 and POSIX 12
- II.B. ALPHA DESIGN AND IMPLEMENTATION 12
  - II.B.1. Time Constraints 12
  - II.B.2. Technical Design 12
  - II.B.3. NAM Modules 14
- II.C. BETA IMPLEMENTATION 16
  - II.C.1. System Redesign 16
  - II.C.2. Hardware/Software/Network Requirements 18
  - II.C.3. Beta Test Participants 19
  - II.C.4. Schedule 19
  - II.C.5. What Did We Provide? 20
  - II.C.6. Statistics on Responses 20

CHAPTER THREE - Lessons Learned
- III.A. DEVELOPERS' FINDINGS 21
  - III.A.1. Findings During Development and Testing 21
  - III.A.2. Findings From Log Files and Monitoring 22
- III.B. USERS' FINDINGS 22
- III.C. PUBLIC DEMONSTRATIONS AND TRADE PRESS REACTIONS 24

CHAPTER FOUR - Options
- IV.A. CREATE NAM-Lite 26
- IV.B. USE WORLD WIDE WEB FORMS 27
- IV.C. CREAT NATIVE CLIENTS WITH SMALL REWRITE 27
- IV.D. CREATE FRONT END FOR INTERNET TOOLS 27
- IV.E. NAM - THE NEXT GENERATION 27
- IV. F. THROWAWAY NAM 27
- IV.G. OTHER CONSIDERATIONS 28

CHAPTER FIVE - Recommendations
- V.A. SHORT TERM 29
- V.B. LONG TERM 29
- V.C. MANAGEMENT RECOMMENDATIONS 29

GLOSSARY 30

CHAPTER ONE - Background

I.A. WHY A GATEWAY PROTOTYPE?

The National Aeronautics and Space Administration (NASA) Access Mechanism (NAM) was initiated to demonstrate the feasibility of using a graphical user interface (GUI) and intelligent gateway technology to streamline access to sources of Scientific and Technical Information (STI).

The NAM project is based upon a technology known as the Intelligent Gateway Processor (IGP). The IGP concept was pioneered by Lawrence Livermore National Laboratories (LLNL) in 1983 in a joint effort sponsored by NASA, the Department of Energy (DOE), and the Department of Defense (DOD). They adopted a national bureau of standards project known then as the Network Access Machine.

The purpose of the NAM prototype was to demonstrate to the NASA user community the concept of a system of this type is to streamline access to diverse sources of information in the NASA environment. To measure the applicability of the system, it was necessary to obtain feedback from selected users in various occupations. This was accomplished by fielding the system at user sites for a six-month testing period.

The members of the NAM Development Team had experience with intelligent gateway and GUI technologies. The team brought the lessons learned from their previous experiences to NASA. The first step was to evaluate the strengths and weaknesses of the previous implementations and to make decisions about what would and would not meet the NASA requirements.

I.B. PROJECT HISTORY

I.B.1. NASA STI Program Overview

The NASA Scientific and Technical Information (STI) Program was established as a result of the National Aeronautics and Space Act of 1958 to identify world-wide sources of scientific, technical, engineering, and related information; develop required policy statements; facilitate authorized access; and manage delivery of the information to NASA and its customer base. STI is basic and applied research results from the efforts of scientists and engineers. It includes new theory and information obtained from experimentation, observations, instrumentation, or computation in the form of text, numeric data, or images. STI may be further transformed, described, evaluated, and/or synthesized and recorded in print, digital, magnetic, or other media to enhance its communications and its usefulness and value to a wide spectrum of users and uses.

From a historical perspective, NASA was a leader in acquiring and processing STI in the mid 1960s to the late 1970s. The user requirements and the services and products provided by the Program were in harmony. The REmote CONsole (RECON) retrieval engine was the first of its kind to provide users access to NASA's bibliographic database system. In fact, RECON was a model for commercial companies and other Federal agencies. From the late 1970s to 1990, the NASA user requirements became unknown and NASA's operation remained unchanged while other Federal organizations moved ahead. In 1990, NASA was still using the system that was developed in the 1960s with few changes. Beginning in 1990, new management began to implement Total Quality Management (TQM) methodologies to improve the current operations while planning to modernize the fragile Program. One of the projects initiated during this period was the NAM effort.

A strategic vision document prepared by the Program stated, "the focus of our effort will be the development of a global program to encourage the creation and exchange of STI and facilitate its use." To implement this effort the Program needed to know the following:

- The information requirements for the R&D community
- The relevant information sources to meet those requirements
- Ways of facilitating access to those information sources

A team comprised of multiple contractors was formed. Curtis Generous of UUcom is the Senior Technical Manager responsible for the technical design and overall management of the project. Rick Dunbar of UUcom is the Senior Analyst responsible for programming and porting the code to other platforms. Denise Duncan from Logistics Management Inc. (LMI) is the Information Specialist responsible for performing user studies, identifying sources of information, and interfacing and coordinating with users. Duc Tran, under contract to UUcom, is an expert in the use of X.11 OSF/Motif and is responsible for the initial design and programming the GUI. John Lycas (LMI) is the Information Specialist responsible for initial design and researching X servers on PCs. Ardeth Taber-Dudas and Lisa Burdick (both of RMS Associates) are responsible for creating the online help screens and the NAM User Manual and providing overall support.

Judy Hunter, as the Manager of Special Projects for NASA, is responsible for the overall government management of the project.

I.B.2. User Requirements

In 1990, the NASA STI Program conducted a study to evaluate the feasibility of using the IGP and GUI technology to meet the NASA users' requirements for access to online information. The NASA user community consists of NASA researchers, engineers, librarians, managers, and the broader university and aerospace industry communities.

The primary objective of the study was to assess the potential for an intelligent gateway to meet NASA users' requirements for online STI retrieval. The study was limited to a sample of the user community and included NASA's Ames Research Center (ARC), Langley Research Center (LaRC), Lewis Research Center (LeRC), and Goddard Space Flight Center (GSFC).

After the results of the study were gathered and examined, the NAM project scope changed; the prototype's design was expanded to include internal databases to NASA such as RECON, as well as external databases such as STN and WAIS sources. In addition, the prototype design was changed to include peer locating tools. This feature was added in response to the users' expressed need, identified during study interviews.

The Program knew that users needed a simple way to locate and access STI from their offices. They learned that users were using a variety of methods to do this: chatting with coworkers in their group, calling or writing colleagues for referrals to other experts or for information, going to the library or calling the librarians, and, infrequently, directly accessing information sources from their desktops. Their information and support requirements are described in the NASA Gateway Requirements Analysis (NASA TM-104951) published in March, 1991. This document summarizes the alternatives and recommended actions, conclusions, and findings resulting from the study.

There was a high degree of consistency in the user responses regarding the functional requirements of an improved STI delivery system. The requirements of the majority of interviewees can be grouped in three parts:

1. Broader And Deeper Coverage Of Relevant Disciplines. Users expressed a need for comprehensive coverage of the disciplines in which NASA performs basic and applied research. This includes improved subject coverage of engineering, physics, geology, mathematics, electronics and control systems, materials, U.S. and international patents, and life sciences.

2. Improved Identification of Information Sources. Users indicated that they need assistance identifying and retrieving pertinent STI from all major foreign sources, and accessing numerical data sets that result from previous observation-based research. At a minimum, they need assistance in locating STI sources within NASA, the U.S., and internationally, even where gateway access is not feasible.

3. Improved Access to Information Sources. Users specified the need for reliable telecommunications off-Center; for example, simplified electronic mail across varying mail systems and networks and increased information about, and access to, resources. They also need access to some Center library services from their offices. They need to execute simple STI queries from their desktop systems. These queries include querying by parameters other than text--for example, by chemical structure--and retrieving complete documents with graphics intact, browsing STI sources and querying results, and forwarding retrieved foreign materials to a translation service. They should be able to set up queries for automatic execution on a daily, weekly, or as needed basis to keep aware of specific topics.

The requirements report recommended six actions:

1. That the STI Program provide a prototype intelligent gateway for user testing for a minimum of six months to allow users to evaluate the utility of access to new STI sources.

2. That the prototype designers select a limited set of STI sources representing the variety of available on-line STI and having the highest relevancy to the prototype user community. These were to include a source of information on research performed outside the U.S.; sources of chemistry, materials, physics, engineering and patent information; resources; and access to human resources, such as the larger research community and the STI Program staff.

3. That the prototype include the applications most frequently requested by users, and that it have a two-level interface: one level for end-users and one for library staff.

4. That the prototype be based in Center libraries and selected end-user offices.

5. That the prototype use existing networks to provide simplified, reliable telecommunications paths connecting user workstations, the prototype host, and the remote information sources.

6. That all organizations that participate in STI delivery and use be included in the prototype.

A listing of user requirements is shown in Table 1, with comments on how the prototype addressed these requirements.

	User	Tech	Met	Comments
Comprehensive discipline coverage	√	√	B	Alpha-D file, STN-Math, Inspec Beta-All except D, STN-ChemAbs, Medline, ...
Improved source information	√	√	A	Database in Source Locator
Improved access to sources	√		A/B	Usable access to/reliable telecommunications via
Improved telecommunications off-Center	√			Libraries have substandard equipment and resources
Simplified email	√		A/B	Pop up mail/peer locator/user agents
Full text	√			Full text data sources too expensive (requirement technically met)
Multimedia	√			Not technically feasible
Queries based on non-text parameters	√	√		Time constraints
Increased information and access	√	√	A/B	Usenet, ARCHIE, Gopher, Mosaic A B A/B B B
Simple desktop queries	√	√	A/B	
Desktop library access	√		B	Ordering documents, email
Current awareness system	√			Time constraints
Electronic browsing of sources and results	√		A/B	
Textual translation	√			No available on-line translation service
Multi platform support		√		Time constraints
Wide area connectivity PSCNI hosts		√	A/B	
Graphical User Interface		√	A/B	
Multilevel interfaces		√	A/B	
DecNet connectivity (SPAN)		√		
PSCNI		√	A	
NSI		√	B	
Standards based approach		√	A/B	
Simultaneous Search DBs		√		Time constraints
Peer Locator		√	A/B	
Canned queries/batch		√		Time constraints
Customizable forms		√		Time constraints

Table 1. Summary of Prototype Responses to Requirements
* A indicates Alpha prototype version and B indicates Beta prototype version

Design of the NAM, which began in the fall of 1991, was based on users' requirements stated in the NASA Gateway Requirements Analysis document. Other factors that could have an impact on the ability to use rapid prototyping methodologies were also employed. The initial plan was to have a working prototype for testing within a year.

A working version of the prototype was first demonstrated in April 1992 at the NASA STI Managers' Conference.

I.B.3. Conceptual Design

In the summer of 1992, the STI Program assembled a team to respond to the recommendations stated in the requirements report. The team operated under two major constraints: a working prototype was needed within one year, and the budget for hardware, software, and personnel was limited.

The concept for the NAM was a unique approach to STI assistance: a desktop tool to assist scientists, engineers, and information specialists in locating and using a complex mix of resources. These resources included formal and informal sources of information for many disciplines, Internet resources, and channels of communication with fellow scientists and engineers and information professionals. In essence, this system represented an expansion of the definition of STI to include Internet resources and human beings.

In addition to this wider variety of resources, the NAM concept included a higher degree of integration than was heretofore seen in STI systems. This desktop tool had to support (as much as feasible) all the ways users find, get, and use STI, so they would only have to install and use one STI tool. It had to be integrated into the user's desktop environment, so it would be natural to incorporate its use into the normal work patterns. It had to be easy to use (less than a half-day of training) for the beginner, and not constraining to the experienced user. For both integration into the desktop environment (which was primarily that of a UNIX workstation, Macintosh, or personal computer) and ease of use, a graphical user interface was desirable.

With this concept in mind, the team evaluated software available from other agencies and commercial off-the-shelf (COTS) software in terms of its potential for the NAM prototype implementation. Some of these systems are listed below, with a summary of the reasons each was not used in the NAM:

Intelligent Gateway Processor (IGP) Software from Lawrence Livermore National Laboratories (LLNL)
The original IGP technology was developed by LLNL under contract to NASA, DOD, and DOE. The NAM team obtained a copy of this software from LLNL and found it too inflexible, both for the initial modifications to create the NAM prototype and those needed in response to the prototype evaluation. The user interface was limited to terminal emulation, and in general, the software was not modular enough.

Defense Gateway Information System (DGIS) from the Defense Technical Information Center (DTIC)
DTIC was one of the sponsors of the original IGP development at LLNL. DTIC continued development of the software in the DGIS in the 1980s. It had many of the same limitations as the IGP software–a centralized architecture, with users connecting to the host minicomputer via a VT100 terminal emulation; no Application Programming Interface (API); and thus no potential for a GUI. In general, the software would not port well to a distributed computing environment.

Foreign Market Analysis System (FMAS) prototype developed by the Army Materiel Command (AMC)
FMAS was developed based on the DGIS software and had all the limitations of the DGIS software. However, in the VT100 screens, a query form had been used. This type of query preparation screen had been used successfully by engineers at the U.S. Army Laboratories.

The commercial software packages reviewed included Ascent Gateway, STILAS, and Grateful Med.

Control Data Corporation's Ascent Gateway software is a commercial version of the DGIS system. It includes database access and query capability, electronic mail, and internal peer location mechanisms. It lacks a GUI and a distributed architecture.

SIRSI Corporation's STILAS software offered multi-database searches, but no tools for access to 'informal' data sources, such as peers and bulletin boards. It would have required a great deal of modification to provide Internet tools and a GUI. Since all modifications to the software had to be performed by SIRSI corporation, it was not flexible enough for prototype development.

Grateful Med is the National Library of Medicine's (NLM) front end to their Medline database. It consists of a software package that allows asynchronous communications between a Macintosh computer and the host database machine. This package was inflexible and unable to support other communications capabilities (i.e., TCP/IP), was supported only on the Macintosh, and did not support other databases.

After reviewing the feasibility of using existing intelligent gateway software, NASA decided to develop a prototype based on the newer LLNL source code. After a study of the program, it was determined that too many changes and modifications were required to import the functions needed to meet the NASA STI community's requirements. The prototype development was designed, implemented, and coded with the understanding that this was a throwaway system that was to be used solely as a rapid prototype for the purpose of demonstrating the concept to the NASA user community. During the Beta test phase, constant monitoring of the usage of the prototype and ongoing communication with testers allowed for the design to be refined. This resulted in a total of three prototype versions being released, each with features and fixes requested by the test community.

A number of design considerations and practical constraints determined the development environment and the scope of the prototype.

CHAPTER TWO - Prototype

II.A. SYSTEM DESIGN CONSIDERATIONS

II.A.1. Hardware Factors

The hardware requirements for the NAM prototype were as follows:

- That it be well-suited for development. The design team wanted assurance that hardware factors would not impair the software development process. This meant finding an industry standard hardware platform for which tools and software could easily be obtained from third party vendors.
- That it support the networking and communications capabilities needed for NAM. At the time of the original design, many networking protocols were considered. These included TCP/IP, OSI, DECNET, and AppleTalk. The platform had to support all of the above protocols, either as a standard part of the operating system or through add-on hardware/software.
- That it support the GUI interfaces proposed to be used by NAM. This meant that color bitmap screens had to be supported by the hardware.
- That the development team have some knowledge of the hardware environment. This requirement was key to implementing the prototype within a year.
- That it serve as a multi-purpose computing platform. The machine also had to provide local services such as email and basic wide area network services such as routing and domain name support to the local area network shown in Figure 1.

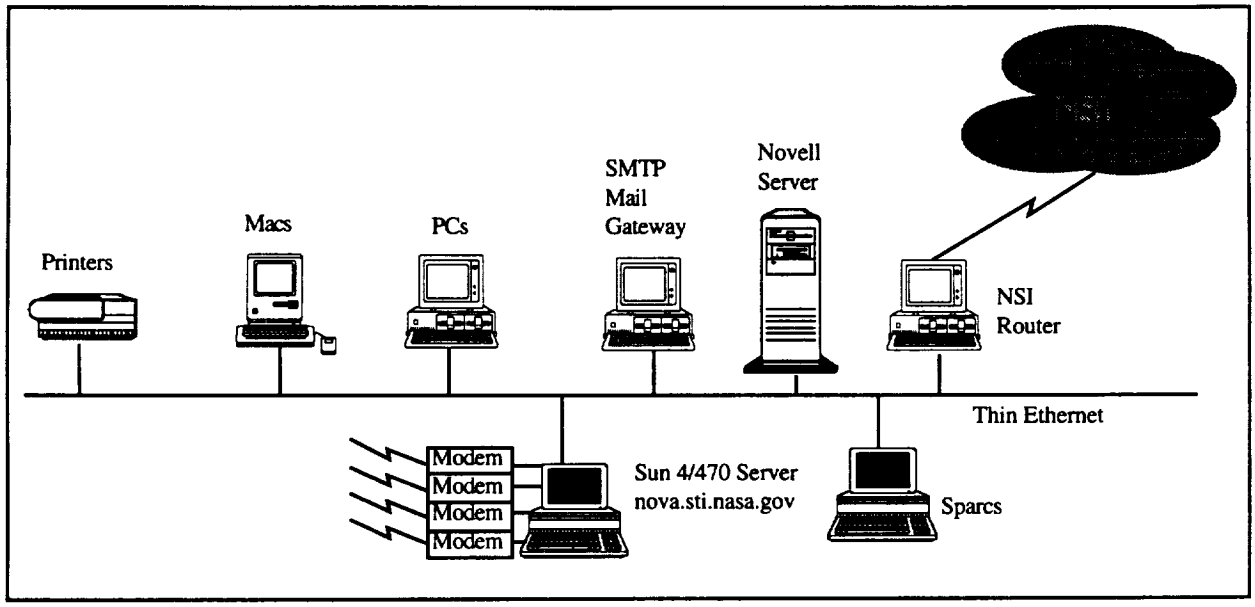


Figure 1. STI Program LAN

II.A.2. Operating System Factors

Additionally, the prototype specification contained requirements that needed to be supported by the operating system:

- Multi-tasking. The NAM prototype server would be supporting many simultaneous users concurrently.
- OS support of networking facilities. The networking capabilities of the hardware needed to be supported as an integral part of the system. The design team's experience with the socket level abstraction provided by many OSs strengthened this requirement.
- Process control capabilities. The distributed client/server design approach required that the OS include background processing, process control, and violation protection.
- User access control. Because the NAM server supports simultaneous users, the OS facilities should support the concept of user identification and provide facilities for authentication and authorization. This would give the NAM server the capability of accessing and granting permissions to individual users, and groups of users, and source or target host identification.
- Must comply with FIPS requirements to meet all POSIX specifications, including P1003.1.

After reviewing all of these above requirements, the UNIX-based operating system (or a variant of) was chosen as the operating system of choice.

II.A.3. Graphical Interface Factors

It was also necessary to decide what windowing environments the graphical user interface (GUI) would support. The NAM development team had several options available to them at this time:

- **Sunview/XView**
  Sunview was immediately rejected due to it's proprietary nature and the fact that the vendor (SUN Microsystems) had announced plans to drop support in the near future.
- **Mac OS**
  The prototype developers had the option of developing a GUI for the Macintosh Operating System (MacOS); however, the intended audience for the prototype included other than Macintosh users and this option was restrictive.
- **Microsoft Windows**
  MS Windows was by far the most popular platform among the intended users. The lack of standardization in development tools and communications API's caused concerns on the support of such a platform.
- The choice of MIT/X11 Revision 4 Windowing System, was made for several reasons:

  It was standards based, as the X protocol was an accepted standard in FIPS PUB 158-1 (IEEE P1295.1)

  It was a widely used environment in the NASA scientific and engineering community.

It was freely available in the public domain with full source code and was a de-facto standard on most workstations such as SUN and Silicon Graphic.

DOS, Microsoft Windows, and MacOS users could be supported by purchasing a commercial X server for their workstations. All users would be able to use the GUI from their own desktop computer.

II.A.4. Development Tools Factors

To facilitate the development effort, it was agreed that the following guidelines should be considered in the selection of an acceptable environment:

- Support industry standard high level language compilers, such as Pascal, or ANSI-C.
- Support standardized Application Programming Interfaces (API) whenever possible to support all of the low level routines.
- Install tools and facilities to support development in a multi-platform, distributed environment. Since the development would be done by several people working on different sections of the application at one time, the ability to support such a work group was necessary.
- Have available proper debugging tools and utilities to support a multiple developer environment; such tools include revision control utilities, linker, preprocessors and incremental loaders.
- Support the Graphical User Interface (GUI) environment that would be selected (see Chapter II.A.4 above).

After careful review of all the available options, and in view of all of the factors and considerations outlined above, the selection of a SUN SPARC was made. The final architecture of the prototype test bed consisted of a SUN 4/470 SPARC server, chosen as the hardware platform for development because it has a robust Operating System (SunOS) and a contract was already in place that would allow the procurement period to be relatively short. Two SUN SPARC IPC workstations were also purchased to be used for development.

Since a UNIX-based development environment was chosen, a rich set of tools was made available for creating the prototype. A compiler for the C programming language is provided with the operating system and is the language of choice of the developers. Many public domain utilities and tools were also used during the development phase of this project, including such facilities as the following:

Perl: an interpreted language optimized for scanning arbitrary text files, extracting information from those text files, and printing reports based on that information. It's also a good language for many system management tasks. The language is intended to be practical (easy to use, efficient, complete) rather than beautiful (tiny, elegant, minimal). It combines some of the best features of C, sed, awk, and sh, so people familiar with those languages should have little difficulty with it. (Language historians will also note some vestiges of csh, Pascal, and even BASIC-PLUS.) Expression syntax corresponds quite closely to C expression syntax. Unlike most UNIX utilities, Perl does not arbitrarily limit the size of your data–if you've got the memory, Perl can slurp in your whole file as a single string. Recursion is of unlimited depth. And the hash tables used by associative arrays grow as necessary to prevent degraded performance. Perl uses sophisticated pattern matching techniques to scan large amounts of data very quickly. Although optimized for scanning text, Perl can also deal with binary data and can make dbm files look like associative arrays (where dbm is available).

Xups: a graphical source level debugger for the C programming language running under the X11 and SunView window systems. It supports both run time debugging with breakpoints and post-mortem debugging from a core file. On Suns you can attach ups to a running process. Xups runs in its own window, thus not interfering with the target program's I/O. The Xups window has two major areas - one showing a structured document representing the target state, the

other showing the source that is being executed.

Zmail: zmail is a MIME-compliant mail user agent (MUA) that can support one of several mail transport agents (MTAs). In its typical configuration, zmail supports SMTP. Zmail supports two interfaces: an X/Motif graphical user interface, and a command line interface.

II.A.5. XWindow Development Toolkit Considerations

Once the selection of an appropriate windowing system was made, the selection of an appropriate toolkit to support the "look and feel" that was desired for the prototype was needed. The options available to the team at the time consisted of :

Xlib
Xlib was eliminated immediately due to the very complex nature of this low-level library, and due to the enormous amount of work necessary to develop original widgets to standardize the look of various forms.

Andrew Toolkit
The Andrew Toolkit was eliminated next because of poor developer support and limited functionality. The Andrew toolkit is a public domain toolkit that was one of the first developed for X11 programmers.

OpenLook (OLIT) Toolkit vs. OSF/Motif
The Open Look toolkit versus OSF/Motif were then the only two choices left. After conducting an informal market survey of software firms and agencies doing their own X11 developments, we found an approximate 3:1 ratio of Motif-based applications over OLIT. The development team chose the OSF/Motif toolkit because it was more widely implemented and this increased the probability of incorporating the NAM gateway with other X11 systems in the future. OSF/Motif is also based on Xlib which would provide a simpler development environment and a more pleasing look and feel. The development staff also had previous experience in developing applications with OSF/Motif.

II.A.6. Networking Considerations

The STI user community is geographically dispersed and therefore presented some constraints on the communications alternatives that were available. The NAM development team had several wide area network alternatives to choose from:

NASA Wide Area Connectivity
NASA's current wide area connectivity includes TCP/IP and DECNET wide area networks provided by the NASA Science Internet (NSI) and the Program Support Computer Networks Internet (PSCNI). Both the NSI and PSCNI provide connectivity between NASA Centers. The PSCNI does not, in general, provide connectivity to the Internet. The NSI is a more open network that is designed to facilitate communications with NASA researchers globally, and as a result provide good Internet connectivity for NASA researches. Our goal was to support the entire NASA research community so we chose the NSI as our wide area network provider.

GOSIP
In addition, there was the need to support GOSIP (Government OSI Profile) which mandates the use of Open Systems Interconnection (OSI) networking protocols where feasible. There is currently very little OSI support and few OSI products available.

Due to the lack of wide area OSI support and products, we chose to use the TCP/IP networking protocol suite due to it's extensive availability and reliability. Furthermore, since TCP/IP was on the NASA Inter Center Council on Networking's (ICCN) list of Approved Short Term Protocols, this would not violate the ICCN mandate during the migrating to OSI. (ICCN is the NASA Council responsible for implementing OSI in the NASA community). The development staff also had extensive

background in the development of TCP/IP based services, and were especially familiar with the socket level abstraction that is provided by most UNIX based platforms. Sockets are an endpoint for communication between processes, similar to the way a telephone is the endpoint of communication between humans. Each socket has queues for sending and receiving data. Sockets are typed according to their communications properties. These properties include whether messages sent and received at a socket require the name of the partner, whether communication is reliable, the format used in naming message recipients, etc.

Communications
To support a truly distributed application, it is imperative that packet level connectivity exists between each module in the NAM application group. The lack of such packet level connectivity can be resolved through the use of several alternative connectivity tools including:

Asynchronous Communications
There was also a need to support asynchronous communications such as dial up access for users who did not have Internet connectivity. This option presented bandwidth limitations. There are a number of ways to support both IP and the X Window System over asynchronous dial-up lines including Serial Line IP (SLIP), which is a widely implemented but non-standardized protocol, and the Point-to-Point Protocol (PPP). PPP has been described and accepted as a standard and offers many built-in features which make the configuration and management of a PPP connection much easier. Performance of a PPP connection is also supposedly higher due to various techniques built-in to the protocol such as Header compression, Type of Service (TOS) prioritizing, automatic IP addressing negotiation, and others.

In general, we decided not to support dial-up access for our test community. We did, however, use asynchronous communications for demonstrations at conferences and at other government agencies.

X Protocol over Serial Line
For those platforms (e.g. Sun's, Hp's) which use the X-Windowing system as the GUI, the use of a specialized X transport protocol over serial lines is also an alternative. There are three known implementations of this capability, two proprietary and one an in-process standard.

- X-Remote - NEC's proprietary implementation of a stripped down X protocol which essentially allows X to run over a non-IP stack. By eliminating the TCP/IP protocol overhead and through the use of compressing and tokenizing techniques, NEC has been able to obtain fairly good benchmarks. Field tests of this technique showed acceptable levels of performance when used in conjunction with V.32bis modems (14.4 Kbaud modems). The display of large graphic images, such as those used in the weather maps on the NAM system, proved to be too slow for acceptable use. Although a proprietary protocol, NEC has released the details of the protocol to the X Consortium which is in the process of making the X-remote a baseline release for the Low Bandwidth X (LBX) protocol in the future release of the X11 Release 6 Windowing system (see LBX below).

- X-Express - Another competing technology attempting to duplicate NEC's proprietary implementation. This protocol was not tested during the Beta test phase since as it became commercially available only during the last few days of the testing period. This approach is also a proprietary technique: there are no plans on making the protocol publicly available.

- Low Bandwidth X (LBX) - NEC's proprietary implementation of a stripped down X protocol has been released to the X Consortium who is in the process of making a slightly

modified version of X-remote as the Low Bandwidth X (LBX) protocol in the future release of the X11 Release 6 Windowing system. Once this process is done (late 1993/early 1994), the definition of LBX will be finalized and published as a standard. No hard data about performance and platform support is yet available to the authors.

II.A.7. Z39.50 and POSIX

At the time of the prototype design, the specification for the 1992 version of the ANSI Z39.50 protocol had not yet been finalized. Furthermore, the handling of non-Z39.50 compliant queries needed to be achieved to handle some of the unusual characteristics of some of the remote data sources being used, and these types of queries did not fit well into the Z39.50-1988 spec. As a result, Z39.50 was not used in the prototype.

POSIX 1003.1 is the IEEE Portable Operating System Interface for Computer Environments. Its goal is to provide a comprehensive operating system environment that application programmers can be confident will be supported across a variety of machines. The IEEE 1003.1-1990 national standard was adopted in April 1933 as FIPS PUB 151-2 POSIX.1. POSIX-1 provides a low-level kernel operations API to support such tasks as process control, signals, file management, etc. At the time of the start of development of the NAM prototype, neither the C compiler nor the interface builder and Motif toolkit supported the POSIX.1 and ANSI-C standards needed to perform POSIX.1 compliant development. For this reason, it was decided to not use the POSIX.1 API.

II.B. ALPHA DESIGN AND IMPLEMENTATION

II.B.1. Time Constraints

Development was started on the Alpha System in December of 1991. The scheduled release of the alpha was June 1992. In February of 1992 the release date was changed from June to April so that a presentation and demo could be made at the annual STI Managers Conference to be held in Houston at the Johnson Space Center. This change in plans finalized what would be in the prototype. The demo also brought forth the need for a SLIP connection for asynchronous communications.

Due to time constraints, many originally planned capabilities of the alpha system had to be cut, including the following:

- Simultaneous searches of various remote databases
- Canned queries and batch processing which would allow users to set up a "current awareness" system for themselves
- The number of remote systems which would be queried
- Accounting features to track cost and usage information
- Non textual queries

II.B.2. Technical Design

The alpha prototype builds on the previous work of many other people; many of its facilities are based on ideas and functions from other projects and are presented in an intuitive, easy-to-use system. For example, query-by-forms interfaces have been used in both structured and unstructured databases. In addition, the Internet tools provided under the Bulletin Boards and Utilities icons were developed by others in the Internet community.

The distributed nature of the NAM prototype was implemented using peer to peer inter-process communications techniques. There are several reasons for this modular design:

- By distributing portions of the application to different processors, a certain amount of replication can be provided to improve reliability of service.

- Improved performance by distributing portions of the application to avoid slow network links or bottlenecks that may exist.

- Improved performance by dedicating machines to be associated with specific tasks, such as database machines, where system load problems might exist.

- Customization for a group or an individual is possible since the functionality of each module is clearly defined and limited in scope. By using the Application Programming Interfaces (API), a site can easily customize the NAM interface to provide specific capabilities needed for their users.

- Supports geographically dispersed users and data collections.

The NAM prototype had several false starts as the programming staff investigated the use of GUI development tools such as NASA's TAE+, Integrated Computer Solution's Xcessory-Builder, and X-Designer. None of those tools fit the requirements of the prototype (limited capability, cost, availability to use OSF/Motif, etc..).

A diagram of the NAM architecture design is depicted in Figure 2. Each module of the NAM is self-contained, capable of communicating with the other modules via a strict transaction protocol, using TCP/IP as the underlying transport mechanism to assure a reliable, bi-directional communications path. The various network capable interfaces among modules are shown in dotted lines, while other interfaces which are internal paths, are shown in solid lines. The communication path among components is provided using TCP/IP-based inter-process communications. This allows all the modules to be running on the same machine or distributed among machines connected via local and wide area networks. Connectivity between the NASA Centers was provided by the NASA Science Internet (NSI), which, in turn, is connected to the rest of the Internet. The NAM prototype was designed to make use of this connectivity to operate.

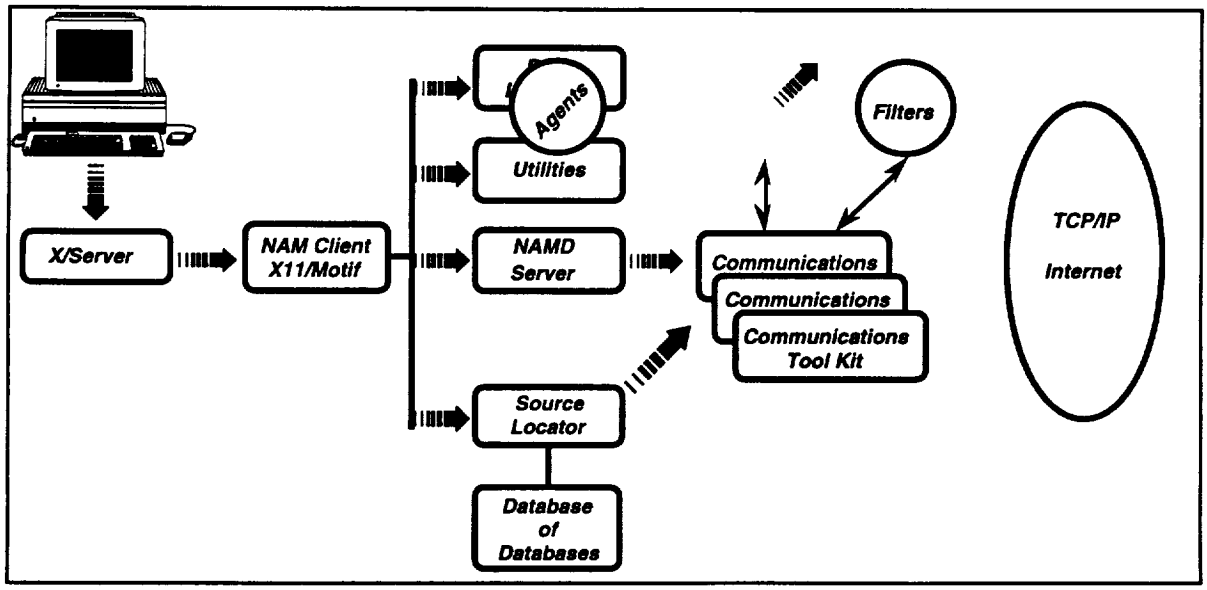


Figure 2. NAM Modules

Support to a limited number of users of dial-up communications has been provided using personal computers with Microsoft Windows, XVision and XRemote software, and high-speed modems for use at exhibits and demonstrations.

II.B.3. NAM Modules

The NAM is composed of nine basic modules:

- Graphical User Interface (GUI)
- Intelligent Source Locator
- Database of Databases
- NAM Server
- Communications Toolkit
- Communications Agents
- Data Filters
- Utilities and Bulletin boards
- Peer Locator Tools

The modules listed above are grouped into several programs that were developed on a Sun SPARC running SunOS 4.1.x. The Graphical User Interface (GUI) consists of two X-window clients that are executed and interact with the user. They are *xnam* and *xconnect.* The second program, *ingd*, is the information server for the Database of Databases and for the digital phonebook. The last program, *namd*, is the NAM server which provides the connectivity to and talks to the remote databases on behalf of the user. These programs communicate with each other over a network.

The NAM Server, Communications Toolkit, Communications Agents, and Data Filters are written in Perl. The rest of the modules are written in the C programming language (K&R). The GUI is based on X11 Release 4 using the OSF/Motif 1.1 toolkit and is currently being ported to X11 Release 5 and the OSF/Motif 1.2.2 toolkit. We are currently porting the code to IBM RS6000 and Silicon Graphics platforms.

The NAM GUI is a custom built windowing application, tailored to the requirements of the STI Program user community. Use of standards compliant software (The X Window System) for the client ensures that the application will be portable to the variety of platforms found in the user community. Use of the OSF/Motif Toolkit provides a unified look and feel on all platforms (UNIX workstations, Microsoft Windows-based personal computers, and Macintosh systems).

The prototype was developed in a distributed, multi-vendor environment, with the use of standards emphasized to maximize the potential for migration to other platforms in future versions. The GUI was implemented as a single X11 client called *xnam*.

Xnam displays the top level icons to the user and responds to his requests. This program uses fork() and exec() to invoke any of the programs found under the email, Bulletin Boards, and Utilities icons. All of these programs are stand-alone applications that have been integrated into NAM for ease of use.

To use the NAM, one's desktop computer must be able to display an X-window. DOS-Based and Macintosh computers must have an X-Window manager installed for this to happen. The NAM developers did an informal study of existing Xserver software based on reliability, speed, and ease of installation and maintenance and chose several for use with the NAM GUI. The software products chosen are listed in Table 2 below.

Hardware	Operating Systems	X Window Managers	X11 Server
IBM PC Clones	DOS with MS-Windows	VisionWare, eXceed	R5
Macintosh	MacOS	MacX, eXodus	R4
Sun SPARC	SunOS 4.1.X	mwm,twm,ctwm, olwm,tvtwm	R4, R5
IBM RS6000	AIX	mwm	R4
Silicon Graphics	IRIX	4DWM	R4

Table 2. X11 Servers

The user's computer must be connected to a TCP/IP network which can access the Internet or use an asynchronous protocol for X11 over serial lines such as XRemote or LBX.

The Intelligent Source Locator
The intelligent source locator was implemented under the Data Sources icon in the GUI. The locator was implemented to allow users to query on a subject without knowing which formal source contained the information. The locator provides the following services:

- Provide a list of databases
- Provide a list of subjects
- Locate appropriate sources on the known subjects.

The Database Of Databases
The Database of Databases is the database that contains the information about the formal data sources that NAM provides access to. In addition, the data used by the NASA phone book under the Peer Locator Icon is maintained under the same database management system. The databases and their subject coverage is manually maintained by the developers.

The server's database contains the Database of Databases, the digital NASA phone book, subject lists, connections data, and costing data. The Database of Databases maintains the records of remote sources, their subject coverage, and relevance scores for each subject.

Xconnect is launched when a user requests to connect to a database. This program manages all of the query-by-forms screens, communicates with the NAM server, and controls the display of output from the communications toolkit. The internal routines extract relevant information from the form, generate a valid query syntax for the remote host, and then ships that query out. Currently, the query strings are built on the server in Crystal City, VA and then sent to the remote database. A historical track of all queries is kept and is viewable by the user to allow him to review a particular search strategy.

The NAM Server
The NAM server is a concurrent process that spawns a copy of itself for connection so that a large number of users may access it at any given time. The server provides user authentication and authorization, and also logs all activity. The NAM server incorporates the following:

- Communications Toolkit
- Communication Agents
- Data Filters

Communications Toolkit
The Communications Toolkit provides a modular approach to providing communications capability to information retrieval systems external to the NAM. This facilitates modification of the user interface in response to user testing, while not affecting the server code. Another module provides batch and delayed operations. That spawns the appropriate agent and accepts commands from the remote user.

The Communications Agents
The Communications Agents are PERL scripts spawned by the Communications Toolkit that connect and communicate with the remote database on behalf of the user.

The Data Filters
The Data Filters provide reformatting functions. They decode the data coming from the remote host and translate them to a standard format to be used by the GUI. Tags used for various headings are translated into English; time and date stamps are put into a common format; and user prompts are eliminated. The data filters are built into the communications agents. The filters are maintained by the developers.

Utilities and Bulletin Boards
Everything that falls under the Bulletin Boards and Utilities main icons are tools that are freely distributed on the Internet.

They are all X applications that work on a variety of hardware platforms and operating systems and have been integrated into the NAM for ease of use for the NASA STI user community. The table below shows which utilities were available under these icons for the ALPHA prototype.

Utility	Actual Program
Usenet News	nn news reader
ARCHIE	xarchie version 1.3
Local Time	xclock
Weather Forecast	xforecast
Weather Maps	fetchmaps and xloadimage

Table 3. Alpha Version Utilities and Bulletin Boards

Peer Locator
This module consists of the following tools:

- finger
- NASA Phone Book
- whois

Query-by-form interfaces are provided to all of these tools as well as *a pop-up email* function. This allows a user to *click* on the email address of the person being searched for and immediately send mail without typing the address of the recipient.

The UNIX *finger* and *whois* commands are available to dynamically query NASA and non-NASA machines. The NASA Phone Book provided in NAM is a static collection of digital telephone directories obtained from the NASA Centers during the beginning of the prototype. These data are stored in a local Ingres database

II.C. BETA IMPLEMENTATION

II.C.1. System Redesign

The beta version of the software addressed many internal problems dealing with data manipulation, and the presentation of the application stayed essentially the same. Several of the changes were made as users were beta testing the system and citing problems to the developers. A list of the major changes from the alpha version to the beta version are noted below.

GUI
The beta version gained increased performance by keeping all data structures in memory. The alpha version used a number of temporary files to store data downloaded from remote databases. This change was a major efficiency and speed gain at the expense of larger memory requirements.

In the alpha version the INGRES database calls were hard coded into the X11 GUI. This dependency was removed. A new network server process was created (called *ingd*). Now the GUI establishes a connection to the database server when queries are made via the Source Locator or NASA digital Phone Book.

The GUI was split into two separate X11 client programs. The *xconnect* program was responsible for establishing a connection to the NAM server (namd), controlling the query by forms screens, and for translating the query to be sent to the remote database. The *xnam* program was responsible for displaying the main icon box, providing job control for invoked processes, and invoking xconnect when connections to the formal data sources were required. The following major changes were also made:

- Under the data sources icon, additional sources were made available. MEDLINE and Chemical Abstracts were made available through STN as requested by some of the beta testers.

- STN was no longer searchable by journals.

- The *file D* collection within NASA RECON was disabled due to the fact that there are limited access records there which could not be made available to the general public.

- Native mode connections were added to support expert searchers who did not wish to be restrained by the forms interface.

- A number of the selection screens were simplified or removed.

- An optional status window was created to record billing costs for the various databases.

- The long citation display was formatted for easier reading by using bold facing and an easier to read format.

Intelligent Source Locator
The intelligent resource locator module provides information about the various remote sources and their coverage of subjects of interest to the users. It provides a mechanism to update a source's relevance score for the chosen subject, based on the user's disposition of search results from that source. The locator was changed to use a new program called *ingd* to query the Database of Databases which maintains the records of remote sources, their subject coverage, and relevance scores for each subject.

Database Server
In the alpha version the INGRES database calls were hard coded into the X11 GUI. This dependency was removed in the beta version. A new network server process was created (called ingd). Now the GUI establishes a connection to the database server when queries are made via the source locator or NASA digital phonebook.

The *ingd* is a concurrent server that accepts a set of well defined requests, queries the database server, and returns the results. See Table 4.

Request	Description
help	Return list of valid commands
dblist	Return list of databases
Subject list	Return list of subjects
locatedb "subject"	Locate db based on subject
locperson "first" "middle" "last" "code" "center	Return phonebook data

Table 4. Defined Set of Requests

Email
Electronic mail is provided in two basic flavors. There are email interfaces such as Elm and ZMail provided to allow users to send, receive, filter, and file their electronic mail. There is also a custom "pop up" mail interface available in the Data Sources and Peer Locators. This facility is used to email search results to the user when searching the data sources. It's also used in the Peer Locator when a search yields a email address.

Utilities and Bulletin Boards
A number of useful tools became available on the Internet and were incorporated under the Bulletin Board and Utilities icons. They included ARCHIE, mosaic and gopher. Weather maps and satellite images were also made available to demonstrate to users the capability to download graphics.

Table 5 shows the publicly available programs incorporated into the Beta Prototype.

Utility	Actual Program
Usenet News	xrn version 6.17
ARCHIE	xarchie version 1.3
WAIS	xwais from free WAIS-0.1
World Wide Web	xmosaic version 1.1
Gopher	xgopher version 1.3
Local Time	sunclock
Weather Forecast	xforecast
Weather Maps	fetchmaps and xloadimage

Table 5. Beta Version Utilities and Bulletin Boards

Peer Locator Tools
Under the peer locator icon, the Knowbot and DNS queries were removed. The Knowbot program did not work properly, and the DNS query function was not useful or understandable by most users. The X.500 services were added because NASA, as an agency, had decided to support X.500 Directory Service Agents (DSA's) at each of the NASA Centers to simplify electronic mail addressing. The Digital NASA phonebook that we had originally collected was allowed to stagnate since an up-to-date X.500 system seemed provide current data.

II.C.2. Hardware/Software/Network Requirements

For the prototype test, the NAM software was maintained on a single server with the IP address nova.sti.nasa.gov, in Arlington, Virginia; both the NAM client and the server ran on that machine. This processor is connected to the Internet via the NASA Science Internet (NSI). Users received an account on nova.sti.nasa.gov, connected via the Internet, and then executed the application; the display of each session was transmitted back to the user's local workstation and displayed using an X Window manager. Thus there were two basic requirements of beta testers: 1) their PCs, Macs, or UNIX workstations had to have TCP/IP connectivity to the Internet, and 2) they had to be able to display an X Window. See Figure 3.

The first requirement, Internet connectivity, eliminated many of the NASA libraries from the beta test, since most did not have TCP/IP connectivity to the Internet. Other libraries were not allowed to participate because their local network administrators felt that X Window-based applications would cause too much network traffic on their local

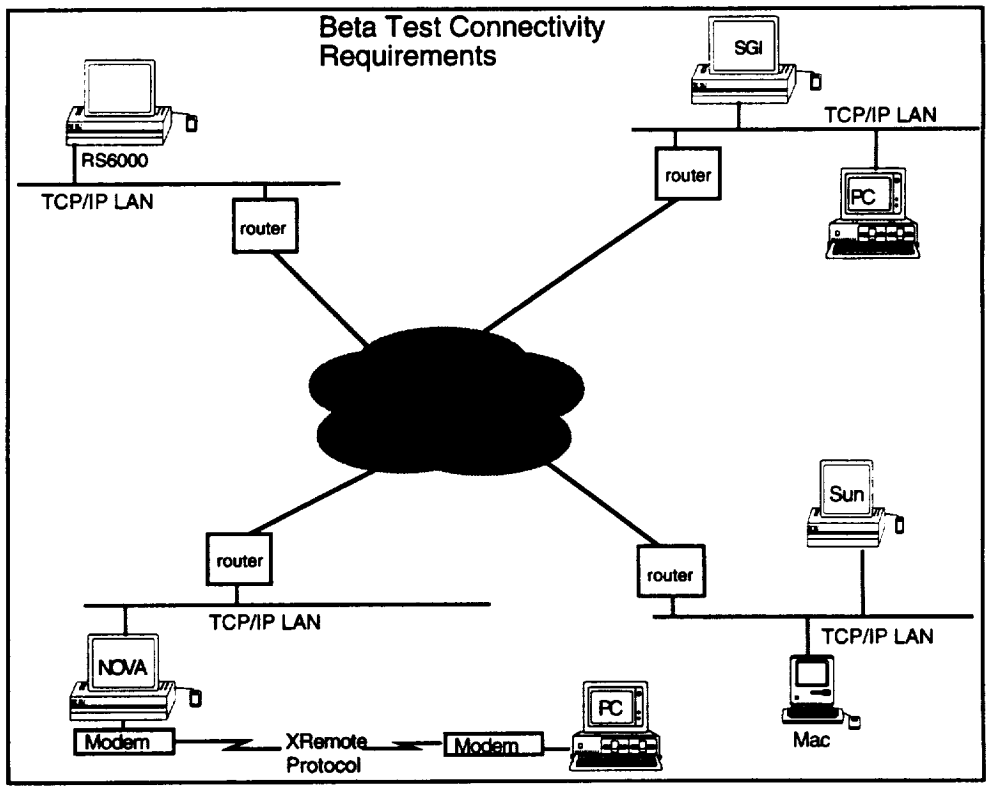


Figure 3. NAM Prototype Connectivity Requirements

area network. This was not true, but they could not be persuaded otherwise.

The second requirement, X-Window capabilities, did not eliminate many NASA employees or on-site contractors; the majority of these beta testers already had the X Windows display capability. Where necessary, the NASA STI Program was able to supply limited numbers of users with the X server software needed for PCs and Macs, including eXodus, eXceed, or XVision for the PC, and MacX or eXodus for the Macintosh. For the UNIX workstations, no software was purchased, since X Windows capability is generally included with that class of workstation. If not supported by the vendor for a particular UNIX workstation, the entire X11 Release 5 is available at no cost on the Internet via anonymous ftp.

II.C.3. Beta Test Participants

The requirements analysis report recommended testing the prototype with a minimum of fifty users for a period of six months. After the initial demonstration of NAM at the STI Managers' Meeting in Houston in April 1992, we solicited participation from the NASA Center libraries. Our hope was that the libraries would both participate as users in the beta test and assist in assembling a good sample of end-users by displaying the system in an open area. However, network connectivity requirements eliminated most of the Center libraries that wanted to participate in the beta test. Only three beta testers came from the libraries or library referrals; the majority of the beta testers were people who saw NAM demonstrated by a colleague or at a trade show and wished to participate in testing. Participants for the beta test were limited to NASA employees and contractors who were U.S. citizens.

As word of the prototype spread, the NAM team began receiving requests for beta test accounts. This resulted in gradual growth in the number of beta testers to a total of forty by the end of the test period, instead of a sample of fifty testers for the entire six-month period. A complete list of the participants and their organizations are listed in Appendix A.

II.C.4. Schedule

Date	Phase
Nov-91	Technical Design
Dec-91	Start Development
Apr-92	Alpha Demo @ STI Conf.
Jun-92	Original Alpha Due Date
Aug-92	Disk Drives Delivered
Dec-92	Begin Beta Test With Six Users
Jan-93	Present NAM at AIAA Meeting
Jan-93	Add 14 Testers
Feb-93	Add 10 Testers
Apr-93	Add 1 Tester
May-93	Add 9 Testers, GCN Article
Jun-93	End Official Beta Test
Jul-93	Computerworld Article
Jul-93 >	Over 250 Inquiries

Table 6. Project Schedule

The requirements analysis report was delivered in March 1991. Market analysis began immediately to determine if there were suitable products available (from commercial or other sources) to meet the requirements. In July 1991, the development team was assembled and conceptual design began; in November 1991, technical design started. Development of the software began in December of 1991, with a due date of June 30, 1992 for demonstration of the alpha version. In February, 1991, the schedule was changed, to have a demonstration of the system at the April, 1992 STI Managers' Meeting. On April 28, a working version of the NAM was demonstrated to attendees at that meeting.

During the summer of 1992, additional disk drives were procured to provide the additional space for user accounts; during this time, the alpha version was revised to include more tools and to make the software more robust. Also during this time, many vendors' versions of the X

server software for Macintosh and PC platforms were evaluated, and the packages to be supported were selected. Internal testing was performed by the development team and JTT users, and a user's manual was produced.

The beta version of the software was completed in the fall of 1993, and beta testers were solicited in November 1993. The six-month testing period began December 1, 1992 and was completed May 31, 1993. Users were added gradually, since the majority of the users nominated themselves for the beta test after seeing the NAM on a colleague's desktop or at an exhibit. Thus, most users formally evaluated the NAM over a period shorter than six months. At the end of the beta test period, users were sent evaluation forms via electronic mail for response by the same mechanism.

II.C.5. What Did We Provide?

We provided users with an account on our Sun processor (nova.sti.nasa.gov). They executed the NAM GUI (both the NAM client and server) on nova, and displayed it to their local workstation over the Internet. We provided electronic mail and telephone support to users needing assistance with NAM operation. We also provided initial on-site support for users installing X server software on personal computers or Macintosh workstations. After a number of users had begun using the NAM with no training from the development team, we visited some user sites to offer them training, user manuals, and demonstrations to other potential users. We provided each user with a user manual if they wanted one.

II.C.6. Statistics on Responses

Users were electronically mailed a questionnaire about the prototype application. A copy of the questionnaire is in Appendix A. The answers to the questionnaire (with names omitted) are provided in Appendix B.

User feedback was collected via electronic mail responses. Unfortunately, only a small number of the beta testers responded to the questionnaire. The collected responses were tallied and analyzed.

As illustrated in Figure 4, the most widely used portion of NAM was the Data Sources icon. The graph shows statistics based on actual number of transactions performed during the official beta test period. Bulletin Boards, which were actually the Internet tools, and others, which were the weather maps, were the next most popular items.

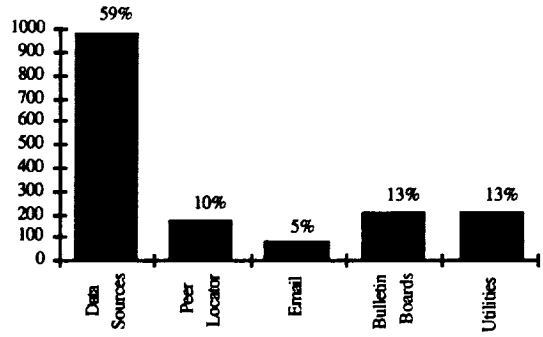


Figure 4. NAM Use by Icon

CHAPTER THREE - Lessons Learned

III.A. DEVELOPERS' FINDINGS

III.A.1. Findings During Development and Testing

Local Availability of NAM GUI
Developers found the biggest problem to be the slowness of the interface when the application was run remotely (as was done in the beta test). The problem was that we were running an X application over a wide area network (WAN), which caused the throughput to be very slow. If the X application approach is to be successful, local concentrations of X-based NAM users should be served by a local machine capable of running the NAM GUI to attempt to maintain the high-bandwidth requirement between the X application and the X display on a local area network (LAN) . This would require that at least one machine be located at each site that would be capable of running the NAM GUI for people who can not run the GUI on their desktop machine (i.e., PCs and Macintosh computers). Users with UNIX-based machines with X11R5 and Motif installed would be best served by installing the application on their own workstations.

Native Clients are Needed for Each Supported Platform
The deployment of the prototype to the different NASA centers pointed out the difficulty in getting an X-Window system running reliably in many different hardware environments. The support of IBM-PCs and clones was especially difficult due to the many differences in hardware/software configurations encountered in the beta test community.

X.500 More Useful Than Electronic Phonebook
The developers stopped updating the electronic phonebook because it required them to continually obtain electronic versions of the phonebook from each center. Each centers' data was in a different format, which made this difficult. Using each centers' X.500 online directory for the phonebook information proved to be more useful, since NASA has made a commitment to keep information in these directories current. It was found, however, that people didn't select X.500 under peer locators because they didn't know what it did; instead they chose the NASA Phonebook option. The X.500 option should have been renamed to reflect its function.

Limited Internet Connectivity to Libraries
Before the beta test phase began, it was assumed that each NASA library would have a running version of the NAM located in an open area of the library. It was soon learned, however, that most of the libraries did not have access to the Internet from local machines. Some libraries did have access, but their LAN administrators did not want X applications running locally because they thought they would cause networks bottlenecks. This lack of connection with libraries placed limits on the Beta Test.

Lack of Adequate Platforms Eliminated Some Testers
Many people expressed great interest in becoming beta testers, but could not due so because their workstations did not meet the minimum system requirements. The X Server software required Microsoft Windows on DOS machines, with at least 8 MB of memory and a VGA monitor. Many systems, especially in the libraries, did not meet these requirements. Macintosh platforms with small monitors and low memory were also eliminated.

PC Xserver Software Selection Cumbersome
A study was done of existing Xserver software to determine the one which was best suited to run the NAM application. The testing and selection of this software took longer than planned, and the selected packages still had occasional bugs.

Dial-in connection to the NAM was supported for demonstrations and exhibits. XRemote performed better than the other serial protocols, PPP and SLIP, for dial-in connections to the NAM, using a 9600 baud modem. XRemote is a proprietary communications protocol developed by NCD. It falls under a technology category referred to as Low-Bandwidth X (LBX). A standard for LBX is expected in X11/R6, to be released in early 1994.

Users Like the Expand Feature
The expand feature allowed users to search for an author or title, and choose from a list of terms that were close to the one searched. Users liked this feature because they did not have to know exactly how to spell an author's name or how it was entered into the database.

III.A.2. Findings From Log Files and Monitoring

Intermediate Form Used Most
Results showed that the Intermediate query form, which allowed users to query on words or phrases found in the abstracts of documents, was used more than the novice or expert. The most common type of query was based on Author name, followed by Subject/Keyword queries. The Intermediate form supported both these query types.

Electronic Phonebooks Popular
Electronic phonebooks were widely used. This capability will be enhanced as more corporate and national electronic phone books and directories become available. The directories need not be global to be useful. Often the organizational level directories were used.

III.B. USERS' FINDINGS

Testers Loved It!
The most common comment was "This is great!" The testers were very happy to have access to NAM, and many have incorporated it's use into their everyday work. That's not to say that there is no room for improvement. During the process of beta testing, users responded with comments and recommendations for the modification of the functional requirements for NAM.

Slow Response Time
The most often heard comment from users was that the NAM application was too slow. The NAM GUI used by the beta testers ran from a machine in Crystal City, Virginia. The GUI was then displayed on the user's workstation over the Internet. This meant that every keystroke and every click of the mouse button had to go over the Internet and back for the user to see anything happen. As a result, the application was slow.

Type of Training Desired
Generally, the testers felt personal training from a knowledgeable user, plus a combination of online instruction (tutorials and more extensive help screens) was the best training environment. They felt the help screens in the beta test version were not very helpful.

More Sources of Information Needed
Most of the users found the NAM interface so useful that they wanted to add more data types and sources of information to those currently available. On average, each user had one or two additions to the information sources provided through the prototype. Types of information requested were as follows:

- Full text
- All NASA papers and technical reports
- Product reviews and descriptions
- Science Citation Index
- Readers' Guide to Periodicals
- Standard reference works
- NASA program descriptions
- NEXUS, LEXIS, DIALOG

- GeoRef
- Non-textual databases
- NASA budget information
- Physical properties tables; flow properties
- Database of people and their expertise
- NASA satellite data (EOSDIS, NSSDC)
- NASA software available for reuse
- COSMIC catalogue
- Educational software
- Images
- Planetary and lunary images available from JPL
- Publicity images available from Public Affairs offices
- Property database (flow database)
- Numerical databases
- Citations index
- Commercial information (Thomas' Register)
- NASA Thesaurus
- DIALOG
- CIA word FACT Book
- Softlib

Single Query Against Multiple Sources
Users would like an option to have the system determine appropriate remote host(s) for a topic, and have the system execute the query against the appropriate source(s). Users should have control of the querying process in all phases (for example, to edit the list of remote sources chosen for execution, or not; to view intermediate results, or not, etc.)

Selective Dissemination of Information
Some users would like the option of creating a standing topic of interest to be executed automatically or at the user's request (also known as selective dissemination of information).

Usenet News Filter
Some users thought it would be useful to be able to query Usenet News categories for specific information so they would not have to search through many messages to find something of interest.

Full Text Retrieval
Once abstracts are retrieved users would like to access full text documents. This has been a requirement mentioned by a majority of the users and should be given high consideration.

Search and Retrieval Techniques
Users want to expand their search and retrieval techniques to include tools other than Boolean logic, such as relevance feedback, natural language queries, and spatial, range, and proximity searching.

User Customization
Users want the ability to customize the query screen to suit their individual search needs.

Local Printing Requested
Once information is retrieved, users need the option to print the results locally at their site. Currently the system directs output to a printer attached to the NAM server in Crystal City.

Action Items Needed for Short Citations
Options currently available for long citations, such as print, save, and FAX, are needed on the short citations screen as well. Many users know a document is needed simply by looking at the title and do not want to view the long abstract before acting on it.

Perform Actions on Multiple Documents
Users would like to be able to act on more than one document at a time. For instance, if they found 50 documents through a search in their area, they would like to be able to mail them all to themselves or choose more than one at a time.

Post Processing Tools
Users requested that post processing tools be available to allow specific transformations to be performed on data obtained from searches. An example given is a duplicate elimination process that would delete multiple instances of the same data found in multiple sources.

Data Visualization
Many sites store data that is non-textual in format. The ability to have various file formats, such as postscript files or numerical data, translated automatically into a readable image is desired by users.

Language Translation
Users need to translate foreign language files as they are transported as well as the terms on which they are searched.

Graphicsl User Interface (GUI) to Databases Easy to Use
The GUI concept was applied to bibliographic database queries by a form on which users filled in blanks corresponding to attributes of the remote database. The forms were the same regardless of the remote database. Users had no difficulty using the forms for single queries and found them to be much easier than learning the query language native to the database being searched. Professional searchers felt that the forms could be made more effective by the addition of tools to use the remote source's Thesaurus and Frequency functions when available.

Minimum Training Required
The NAM Prototype has been used successfully by NASA engineers with no prior training other than a demonstration lasting less than one-half hour. The unique combination of tools to access internal and external information, formal and informal sources, peer location and Internet utilities is applicable in various user environments. Users liked the fact that they did not need a lot of training to use the NAM.

Electronic Phonebooks Popular
Users liked the digital phonebooks to find information about their peers and found them very useful. They especially found the email addresses helpful.

Desktop Access to Infromation Saves Staff Time
Users were asked to estimate the time and/or money they would save per year if they had the NAM available to them from their desktop. Individual estimates of savings ranged from a low of at least one week per year to several weeks per year, and a high of $20,000 per year.

Uses of Desktop Information Access
Users found that they used NAM mostly to stay current in their field or prepare a presentation or paper. The next most important use was to find an expert for collaboration or to help solve a problem. After that the most popular use was to prepare/refine a project proposal. Others used the NAM to train library patrons or to find references via author search.

Predicted Use of NAM
Users were asked to predict the frequency with which they would use the various facilities provided by the prototype. Users predicted that they would use all facilities, with a frequency of use for different facilities ranging from once per month to several times per day.

Users predict that they would use mail and bulletin boards most frequently, followed by access to data sources (in order of frequency: ARIN, and Inspec) followed by utilities and peer locators.

III.C. PUBLIC DEMONSTRATIONS AND TRADE PRESS REACTIONS

In January, 1993, the STI Program exhibit staff began to demonstrate the NASA Access Mechanism at various trade shows, exhibits, and conferences throughout the United States. Public reactions to the NAM varied with the particular exhibit attendees.

Audiences consisting mostly of researchers and NASA employees or contractors were very interested in the Data Sources portion of NAM. They were thrilled to find that someone was trying to make commonly used databases such as STN and RECON user friendly. Most audiences said they currently went to their site library to have searches done for them, and they disliked having to physically go there and then wait for the search being performed. Many people did not know what RECON was; they simply knew that

their librarian found information from some database inside NASA. After a short demonstration of the NAM they were very impressed with the simplicity, and the next question was always, "How can I get it?" or "When will this be available to the public?"

Exhibits that were tailored towards new technology brought different responses from attendees. These audiences were more interested in the Internet tools than the database search mechanisms. They were excited to see that they could have tools such as WAIS, Gopher, Usenet and World Wide Web available to them through one single application. They also wanted to know how they could get NAM put on their desktop workstation.

Although there was a great deal of interest from conference attendees in becoming beta testers for NAM, many of them did not qualify. Some conferences had many attendees from commercial firms to which we could not supply the software. Many of the people did not have Internet access at their desktop, so they would not be able to use NAM. Others became uninterested when they found out they needed to purchase the Xserver software to use NAM on a PC or Macintosh. Generally comments were positive from all groups, and they wanted to know when the software would be publicly available.

As more people learned about the NAM, interest continued to grow. On May 24, 1993 Government Computer News published an article titled, "NASA's Homegrown GUI Scores Big With Beta Testers." (see appendix). This article focused primarily on the background of the NAM project, the systems on which it runs, and the data source portion of the software. It mentioned the other functions of NAM but did not go into great detail about them. This article generated interest, but did not give a point of contact to the readers. Some people still managed to track down the STI program by asking NASA employees how to contact the programmers listed in the article.

On July 5, 1993 Computerworld published an article titled, "NASA's GUI Makes the Internet User Friendly." (see appendix).This article focused on the modularity of the NAM software and graphical user interface to the Internet. The article also informed readers that they could learn more about NAM by sending email to nam@sti.nasa.gov, which forwarded the messages to all members of the NAM team. This article generated interest from over 250 readers who wanted to know when NAM would be available to the public and how they could learn more about it. Those interested received instructions on how to download a technical NAM paper using FTP or a gopher client. More people are getting connectivity, but need help navigating their way to useful information. Many thought that having several tools available through one piece of software was an excellent idea and they wanted to try it themselves. The NAM team was very surprised to learn that most of the interest in the NAM software was based on the tools, not the database search utilities as planned. Tools such as WAIS, gopher, and WWW are publicly available to everyone, but many people do not know how to obtain them and make them run.

CHAPTER FOUR - Options

IV.A. CREATE NAM-Lite

The existing NAM application could be modified so the NAM GUI could be distributed to users. The server portions of NAM can still be run in a more controlled environment. It is recommended that the following changes be made to the current NAM system to create NAM-Lite:

- User authentication
- Limit to RECON, STN and DIALOG connectivity
- Only intermediate and native screens
- Basic peer locator tools provided
- Top level icons modified
- Group/Set operations
- Screens for new account information
- Automatic link to thesaurus
- Source locator redone
- Added Peer Locator tools

The NAM-Lite program should still contain the functionality of RECON and STN. Adding DIALOG as a database source would fill the majority of user requests for external sources. User authentication will need to be built into the system to allow a user to maintain and modify his/her own passwords and userid information. The user will have the option of using STN, DIALOG and RECON, as with the current system, but if they do not have an existing account they will be presented with an informative page on how to get accounts either online or by contacting the respective agency. Once an account has been established, the user will be transparently connected to the remote system as with the current version of NAM.

NAM-Lite should only limit the search form to the intermediate and native screens. The novice screen is unnecessary because the intermediate screen allows for more complex searches by the experienced user but does not make a simple search strategy any more complicated to the novice user. The native mode will be available for those expert users of RECON, STN, or DIALOG. The expert screen will be dropped because it is somewhat limiting for true expert users who want to search using the native system query language.

Basic peer locator tools will still be available with NAM-Lite. The digital phonebooks will be dropped because they are too difficult to keep current. The X.500 service will be available and possibly renamed digital phonebook. Other basic services such as finger, netlib, and whois will remain the same. Adding a new service class such as NetFind would greatly enhance the user's capabilities to locate individuals.

The top level icons will be modified with a whole new look to differentiate them from the current version of NAM. There will only be three main buttons, which will be Data Sources, Peer Locator, and Tools. The tools button will be a user-defined button with which users can link local applications, such as email, WWW, WAIS and gopher.

NAM-Lite should include the capability to perform group operations. Users will be able to select all or multiple sets of data and perform group operations on them such as printing, faxing, or mailing.

An automatic link to the thesaurus will be implemented in NAM-Lite. Users will be able to search on terms, but if they are unclear about a term they can automatically bring up a thesaurus to assist them.

The source locator needs to be updated to connect to accessible file collections and reflect access to collections by user id. Users would be able to connect to classified information if their user id was of a certain class.

Once NAM-Lite is created it can be distributed to the NASA community.

NAM-Lite would replace the current version of the NAM that is being run remotely by users; it would be run locally to obtain maximum speed, which has been a large problem.

The same NAM-Lite described above could be made available to the public. The user authentication process, which gives instructions on how to obtain an account, may spark interest for potential users at universities and research institutions to obtain RECON accounts.

The GUI should be ported to other UNIX variants such as IRIX, HP-UX, and AIX. This would allow for a larger community of potential users to take advantage of the NAM-Lite.

IV.B. USE WORLD WIDE WEB FORMS

Implement the functions of the formal data sources access using the forms functionality of Mosaic/WWW. This will allow us to leverage from the work done at the National Center for Supercomputing Applications (NCSA) on Mosaic. This approach also allows the limited support capabilities of the STI Program to concentrate on the service aspects of the NAM rather than concentrating on the development of native clients. Currently, NCSA provides native clients for UNIX (X11/OSF Motif), MS-Windows, and MacOS platforms.

IV.C. CREAT NATIVE CLIENTS WITH SMALL REWRITE

Native clients could be written for PC (DOS and Windows) and Macintosh platforms that would provide the same functionality as the current NAM system. The European Space Agency (ESA) has developed a MS-Windows based product called BRAQUE (BRowse And QUEry). This system allows PC users connected to either a TCP/IP Internet or via an asynchronous modem to connect to ESA's QUEST system and perform searches using a GUI query-by-forms capabilities. Since the QUEST system takes as its origins the same software that RECON uses, it is anticipated that modification of the source code of BRAQUE to work with RECON would not be too extensive. This would give the STI Program a quick and inexpensive PC platform native client. The ESA folks have stated that they would be willing to give the STI program a copy of the source code for this purpose.

IV.D. CREATE FRONT END FOR INTERNET TOOLS

The icon of the NAM called Bulletin Boards provided the user with a front end to public domain software such as WWW, Archie, gopher, and WAIS. These applications proved to be a very popular portion of NAM and could be isolated into a separate GUI providing easy access to commonly used Internet tools.

The entire design of the NASA Access Mechanism needs to be reconsidered, redesigned, and reimplemented. A new design specification should be written to alleviate problems with the current system and to take advantage of new technology. An Object Oriented Design (OOD) should be used. A GUI that may be easily tailored to individuals or small groups needs should be provided. The GUI should be implemented natively under UNIX/X, MacOS, and Microsoft Windows. New tools and services need to be provided to help users locate and access the data sources they need.

IV. F. THROWAWAY NAM

The first option is to remove all access to the current system. What has been learned from the prototype can be incorporated into the NASA STI Program's RECON Replacement system. This is not a viable option unless the RECON Replacement is implemented in a timely fashion.

IV.G. OTHER CONSIDERATIONS

Issues of distribution, support, and access rights need to be considered. Any user community to whom we provide access to a potential new version of NAM needs to be made aware of data access restrictions.

CHAPTER FIVE - Recommendations

V.A. SHORT TERM

Both the NAM-Lite version and a WWW/Mosaic Forms version of NAM GUI should be developed and made available to the NASA user community as soon as possible. These recommendations suggest interim measures designed to serve our user community until the formal RECON replacement is made available.

The NAM-Lite implementation would be made available in both source and binary forms to allow maximum outside exposure and encourage outside enhancements. The use of either COSMIC and/or anonymous FTP as distribution medium sites is strongly encouraged.

The WWW/Mosaic Forms version, on the other hand, does not require a distribution medium, as the form would simply be made available on the STI's WWW server. This would be a HTML document that would be interpreted by WWW clients such as Mosaic.

Operational support of the NAM-Lite version should be provided by the Information Services Section of the STI Program. Maintenance of the code should be limited to bug fixes and minor enhancements only.

Versions of NAM-Lite must be ported to other common platforms (UNIX, PCs and Mac's).

V.B. LONG TERM

Native clients for MS-Windows, MacOS, and X11
The possibility of modifying the ESA/BRAQUE software to work for MS-Windows platform should be researched. Native clients for Macintoshes also need to be developed. The parts of the current client that are unique should remain consistent from client to client. For other applications that we have integrated like gopher, WAIS, email, etc. we should use the best native client that is available in the public domain.

V.C. MANAGEMENT RECOMMENDATIONS

It is recommended that the current NAM prototype system be modified in a timely manner so that it can become available to the NASA user community as quickly as possible. Functions that are out of date or not used will be removed from the system, and remaining functions will be updated as described in the previous section. This new version of the product will be known as NAM-Lite. Once the product is ready for distribution, the team should do whatever is needed to get the libraries to use the system. The NAM-Lite system should act as an interim system until the RECON Replacement system is in place. Once the RECON Replacement system is in place, the Program will need to evaluate the need for keeping NAM-Lite operational.

Once an operational system is in place, support of the NAM product should be transferred to the Information Services Section of the STI Program. Training will be supplied for the Help Desk staff at CASI so they can handle the questions they receive on a daily basis.

Functions that provide users with an interface to the Internet utilities should be isolated and distributed as a separate system via COSMIC.

It is also recommended that the NASA STI Program's Engineering Review Board discuss the role NASA wants to play in providing a system like NAM to the user community. Does the Program want to support the system forever or distribute the software and let the Centers and Program Offices do as they want? This is a strategy question which will need more discussion.

GLOSSARY

agent
In the client-server model, the part of the system that performs information preparation and exchange on behalf of a client or server application.

American Standard Code for Information Interchange (ASCII)
A standard character-to-number encoding widely used in the computer industry.

anonymous FTP
Anonymous FTP allows a user to retrieve documents, files, programs, and other archived data from anywhere in the Internet without having to establish a userid and password. By using the special userid of "anonymous" the network user will bypass local security checks and will have access to publicly accessible files on the remote system.

AppleTalk
Apple Computer's suite of protocols that enables the hardware and software on an AppleTalk network to interact and to route data.

application
A program that performs a function directly for a user. FTP, mail, and Telnet clients are examples of network applications.

application layer
The top layer of the network protocol stack. The application layer is concerned with the semantics of work (e.g., formatting electronic mail messages). How to represent that data and how to reach the foreign node are issues for lower layers of the network.

Application Program Interface (API)
A set of calling conventions which define how a service is invoked through a software package.

archie
A system to automatically gather, index, and serve information on the Internet. The initial implementation of archie provided an indexed directory of filenames from all anonymous FTP archives on the Internet. Later versions provide other collections of information.

archive site
A machine that provides access to a collection of files across the Internet. An "anonymous FTP archive site," for example, provides access to this material via the FTP protocol.

authentication
The verification of the identity of a person or process.

backbone
The top level in a hierarchical network. Stub and transit networks that connect to the same backbone are guaranteed to be interconnected.

bandwidth
Technically, the difference, in Hertz (Hz), between the highest and lowest frequencies of a transmission channel. However, as typically used, bandwidth is the amount of data that can be sent through a given communications circuit.

Berkeley Software Distribution (BSD)
Implementation of the UNIX operating system and its utilities developed and distributed by the University of California at Berkeley. "BSD" is usually preceded by the version number of the distribution, e.g., "4.3 BSD" is version 4.3 of the Berkeley UNIX distribution. Many Internet hosts run BSD software, and it is the ancestor of many commercial UNIX implementations.

Bulletin Board System (BBS)
A computer, and associated software, which typically provides electronic messaging services, archives of files, and any other services or activities of

interest to the bulletin board system's operator. Although BBSs have traditionally been the domain of hobbyists, an increasing number of BBSs are connected directly to the Internet, and many BBS's are currently operated by government, educational, and research institutions.

client
A computer system or process that requests a service of another computer system or process. A workstation requesting the contents of a file from a file server is a client of the file server.

client-server model
A common way to describe the paradigm of many network protocols. Examples include the name-server/name-resolver relationship in DNS and the file-server/file-client relationship in NFS.

connection-oriented
The data communication method in which communication proceeds through three well-defined phases: connection establishment, data transfer, and connection release. TCP is a connection-oriented protocol.

connectionless
The data communication method in which communication occurs between hosts with no previous setup. Packets between two hosts may take different routes, as each is independent of the other. UDP is a connectionless protocol.

datagram
A self-contained, independent entity of data carrying sufficient information to be routed from the source to the destination computer without reliance on earlier exchanges between this source and destination computer and the transporting network.

DECNET
A proprietary network communication protocol by Digital Equipment Corporation which is widely is use today

Defense Advanced Research Projects Agency (DARPA)
An agency of the U.S. Department of Defense responsible for the development of new technology for use by the military. DARPA (formerly known as ARPA) was responsible for funding much of the development of the Internet we know today, including the Berkeley version of UNIX and TCP/IP.

Defense Data Network (DDN)
A global communications network serving the U.S. Department of Defense composed of MILNET, other portions of the Internet, and classified networks that are not part of the Internet. The DDN is used to connect military installations and is managed by the Defense Information Systems Agency.

Defense Data Network Information Center (DDN NIC) Often called "The NIC," the DDN NIC's primary responsibility is the assignment of Internet network addresses and Autonomous System numbers, the administration of the root domain, and providing information and support services to the DDN. It is also a primary repository for RFCs.

dialup
A temporary, as opposed to dedicated, connection between machines established over a standard phone line.

Directory Access Protocol
X.500 protocol used for communication between a Directory User Agent and a Directory System Agent.

Directory System Agent (DSA)
The software that provides the X.500 Directory Service for a portion of the directory information base. Generally, each DSA is responsible for the

directory information for a single organization or organizational unit.

Directory User Agent (DUA)
The software that accesses the X.500 Directory Service on behalf of the directory user. The directory user may be a person or another software element.

Distributed Computing Environment (DCE)
An architecture of standard programming interfaces, conventions, and server functionality (e.g., naming, distributed file system, remote procedure call) for distributing applications transparently across networks of heterogeneous computers. Promoted and controlled by the Open Software Foundation (OSF), a consortium led by Digital, IBM, and Hewlett Packard.

distributed database
A collection of several different data repositories that looks like a single database to the user. A prime example in the Internet is the Domain Name System.

Domain Name System (DNS)
The DNS is a general purpose distributed, replicated, data query service. The principal use is the lookup of host IP addresses based on host names. The style of host names now used in the Internet is called "domain name," because they are the style of names used to look up anything in the DNS. Some important domains are .COM (commercial), .EDU (educational), .NET (network operations), .GOV (U.S. government), and .MIL (U.S. military). Most countries also have a domain. For example, .US (United States), .UK (United Kingdom), .AU (Australia).

Electronic Mail (Email)
A system whereby a computer user can exchange messages with other computer users (or groups of users) via a communications network. Electronic mail is one of the most popular uses of the Internet.

email address
The domain-based or UUCP address that is used to send electronic mail to a specified destination.

Ethernet
A 10-Mb/s standard for LANs, initially developed by Xerox and later refined by Digital, Intel and Xerox (DIX). All hosts are connected to a coaxial cable where they contend for network access using a Carrier Sense Multiple Access with Collision Detection (CSMA/CD) paradigm.

Federal Information Exchange (FIX)
One of the connection points between the American governmental internets and the Internet.

Fiber Distributed Data Interface (FDDI)
A high-speed (100Mb/s) LAN standard. The underlying medium is fiber optics, and the topology is a dual-attached, counter-rotating token ring.

file transfer
The copying of a file from one computer to another over a computer network.

File Transfer Protocol (FTP)
A protocol that allows a user on one host to access and transfer files to and from, another host over a network. Also, FTP is usually the name of the program the user invokes to execute the protocol. It is defined in STD 9, RFC 959.

finger
A program that displays information about a particular user, or all users, logged on the local system or on a remote system. It typically shows full name, last login time, idle time, terminal line, and terminal location (where applicable). It may also display plan and project files left by the user.

gateway
The term "router" is now used in place of the original definition of "gateway". Currently, a gateway is a communications device/program that passes data between networks having similar functions but dissimilar implementations. This should not be confused with a protocol converter. By this definition, a router is a layer 3 (network layer) gateway, and a mail gateway is a layer 7 (application layer) gateway.

gopher
A distributed information service that makes available hierarchical collections of information across the Internet. Gopher uses a simple protocol that allows a single Gopher client to access information from any accessible Gopher server, providing the user with a single "Gopher space" of information. Public domain versions of the client and server are available.

Government OSI Profile (GOSIP)
A subset of OSI standards specific to U.S. Government procurements, designed to maximize interoperability in areas where plain OSI standards are ambiguous or allow excessive options.

host
A computer that allows users to communicate with other host computers on a network. Individual users communicate by using application programs, such as electronic mail, Telnet, and FTP.

hostname
The name given to a machine.

Interagency Interim National Research and Education Network (IINREN)
An evolving operating network system. Near term (1992-1996) research and development activities will provide for the smooth evolution of this networking infrastructure into the future gigabit NREN.

International Organization for Standardization (ISO)
A voluntary, non-treaty organization founded in 1946 that is responsible for creating international standards in many areas, including computers and communications. Its members are the national standards organizations of the 89 member countries, including ANSI for the U.S.

internet
While an internet is a network, the term "internet" is usually used to refer to a collection of networks interconnected with routers.

Internet
(Note the capital "I.") The Internet is the largest internet in the world. It a three-level hierarchy composed of backbone networks (e.g., NSFNET, MILNET), mid-level networks, and stub networks. The Internet is a multiprotocol internet.

internet address
A IP address that uniquely identifies a node on an internet. An Internet address (capital "I") uniquely identifies a node on the Internet.

Internet Protocol (IP)
The Internet Protocol, defined in STD 5, RFC 791, is the network layer for the TCP/IP Protocol Suite. It is a connectionless, best-effort packet switching protocol.

Internetwork Packet eXchange (IPX)
Novell's protocol used by Netware. A router with IPX routing can interconnect LANs so that Novell Netware clients and servers can communicate.

interoperability
The ability of software and hardware on multiple machines from multiple vendors to communicate meaningfully.

Kermit
A popular file transfer protocol developed by Columbia University.

Because Kermit runs in most operating environments, it provides an easy method of file transfer. Kermit is NOT the same as FTP.

knowbot
An experimental directory service.

layer
Communication networks for computers may be organized as a set of more or less independent protocols, each in a different layer (also called level). The lowest layer governs direct host-to-host communication between the hardware at different hosts; the highest consists of user applications. Each layer builds on the layer beneath it. For each layer, programs at different hosts use protocols appropriate to the layer to communicate with each other. TCP/IP has five layers of protocols; OSI has seven. The advantages of different layers of protocols is that the methods of passing information from one layer to another are specified clearly as part of the protocol suite, and changes within a protocol layer are prevented from affecting the other layers. This greatly simplifies the task of designing and maintaining communication programs.

listserv
An automated mailing list distribution system originally designed for the Bitnet/EARN network. *See also* Bitnet, European Academic Research Network, mailing list.

Local Area Network (LAN)
A data network intended to serve an area of only a few square kilometers or less. Because the network is known to cover only a small area, optimizations can be made in the network signal protocols that permit data rates up to 100Mb/s. *See also* Ethernet, Fiber Distributed Data Interface, Wide Area Network.

mail server
A software program that distributes files or information in response to requests sent via email. Internet examples include Almanac and netlib. Mail servers have also been used in Bitnet to provide FTP-like services. *See also* Electronic Mail, File Transfer Protocol.

Multipurpose Internet Mail Extensions (MIME)
An extension to Internet email that provides the ability to transfer non-textual data, such as graphics, audio and fax. It is defined in RFC 1341.

National Institute of Standards and Technology (NIST)
United States governmental body that provides assistance in developing standards. Formerly the National Bureau of Standards.

National Research and Education Network (NREN)
The NREN is the realization of an interconnected gigabit computer network devoted to High Performance Computing and Communications.

National Science Foundation (NSF)
A U.S. government agency whose purpose is to promote the advancement of science. NSF funds science researchers, scientific projects, and infrastructure to improve the quality of scientific research. The NSFNET, funded by NSF, is an essential part of academic and research communications. It is a high speed "network of networks" that is hierarchical in nature. At the highest level, it is a backbone network currently comprising 16 nodes connected to a 45Mb/s facility that spans the continental United States. Attached to that are mid-level networks and attached to the mid-levels are campus and local networks. NSFNET also has connections out of the U.S. to Canada, Mexico, Europe, and the Pacific Rim. The NSFNET is part of the Internet.

network
A computer network is a data communications system that interconnects computer systems at various different sites. A network may be composed of any combination of LANs or WANs.

network address
The network portion of an IP address. For a class A network, the network address is the first byte of the IP address. For a class B network, the network address is the first two bytes of the IP address. For a class C network, the network address is the first three bytes of the IP address. In each case, the remainder is the host address. In the Internet, assigned network addresses are globally unique. *See also*: Internet.

Network File System (NFS)
A protocol developed by Sun Microsystems and defined in RFC 1094 that allows a computer system to access files over a network as if they were on its local disks. This protocol has been incorporated in products by more than two hundred companies, and is now a de facto Internet standard.

Network Information Center (NIC)
A NIC provides information, assistance, and services to network users.

Network Information Services (NIS)
A set of services, generally provided by a NIC, to assist users in using the network.

Network News Transfer Protocol (NNTP)
A protocol, defined in RFC 977, for the distribution, inquiry, retrieval, and posting of news articles.

node
An addressable device attached to a computer network. *See also*: host, router.

Open Systems Interconnection (OSI)
A suite of protocols, designed by ISO committees, to be the international standard computer network architecture.

OSI Reference Model
A seven-layer structure designed to describe computer network architectures and the way that data passes through them. This model was developed by the ISO in 1978 to clearly define the interfaces in multivendor networks and provide users of those networks with conceptual guidelines in the construction of such networks.

packet
The unit of data sent across a network. "Packet" is a generic term used to describe a unit of data at all levels of the protocol stack, but it is most correctly used to describe application data units. *See also* datagram.

Packet InterNet Groper (PING)
A program used to test reachability of destinations by sending them an ICMP echo request and waiting for a reply. The term is used as a verb: "Ping host X to see if it is up!"

Point-to-Point Protocol (PPP)
The Point-to-Point Protocol, defined in RFC 1171, provides a method for transmitting packets over serial point-to-point links.

port
A port is a transport layer demultiplexing value. Each application has a unique port number associated with it. *See also* Transmission Control Protocol.

postmaster
The person responsible for taking care of electronic mail problems, answering queries about users, and other related work at a site.

protocol
A formal description of message formats and the rules two computers must follow to exchange those messages. Protocols can describe low-level details of machine-to-machine interfaces (e.g., the order in which bits and bytes are sent across a wire) or high-level exchanges between allocation programs (e.g., the way in which two programs transfer a file across the Internet).

protocol stack
A layered set of protocols that work together to provide a set of network functions.

queue
A backup of packets awaiting processing.

remote login
Logging in on a remote computer, using a protocol over a computer network, as though locally attached.

Remote Procedure Call (RPC)
An easy and popular paradigm for implementing the client-server model of distributed computing. In general, a request is sent to a remote system to execute a designated procedure, using arguments supplied, and the result returned to the caller. There are many variations and subtleties in various implementations, resulting in a variety of different (incompatible) RPC protocols.

Request For Comments (RFC)
The document series, begun in 1969, that describes the Internet suite of protocols and related experiments. Not all (in fact very few) RFCs describe Internet standards, but all Internet standards are written as RFCs. The RFC series of documents is unusual in that the proposed protocols are forwarded by the Internet research and development community, acting on their own behalf, as opposed to the formally reviewed and standardized protocols that are promoted by organizations such as CCITT and ANSI.

route
The path that network traffic takes from its source to its destination. Also, a possible path from a given host to another host or destination.

router
A device that forwards traffic between networks. The forwarding decision is based on network layer information and routing tables, often constructed by routing protocols.

routing
The process of selecting the correct interface and next hop for a packet being forwarded.

Serial Line IP (SLIP)
A protocol used to run IP over serial lines, such as telephone circuits or RS-232 cables, interconnecting two systems. SLIP is defined in RFC 1055.

server
A provider of resources (e.g., file servers and name servers).

Simple Mail Transfer Protocol (SMTP)
A protocol, defined in STD 10, RFC 821, used to transfer electronic mail between computers. It is a server-to-server protocol, so other protocols are used to access the messages.

SLIP
See Serial Line IP.

snail mail
A pejorative term referring to the U.S. Postal Service.

TCP/IP Protocol Suite
Transmission Control Protocol over Internet Protocol. This is a common shorthand that refers to the suite of transport and application protocols that runs over IP.

Telnet
Telnet is the Internet standard protocol for remote terminal connection service. It is defined in STD 8, RFC 854 and extended with options by many other RFCs.

Transmission Control Protocol (TCP)
An Internet Standard transport layer protocol defined in STD 7, RFC 793. It is connection-oriented and stream-oriented, as opposed to UDP.

Usenet
A collection of thousands of topically named newsgroups, the computers that run the protocols, and the people who read and submit Usenet news. Not all Internet hosts subscribe to Usenet and not all Usenet hosts are on the Internet.

virtual circuit
A network service that provides connection-oriented service regardless of the underlying network structure.

white pages
The Internet supports several databases that contain basic information about users, such as email addresses, telephone numbers, and postal addresses. These databases can be searched to get information about particular individuals. Because they serve a function akin to the telephone book, these databases are often referred to as "white pages".

WHOIS
An Internet program that allows users to query a database of people and other Internet entities, such as domains, networks, and hosts, kept at the DDN NIC. The information for people shows a person's company name, address, phone number, and email address.

Wide Area Information Servers (WAIS)
A distributed information service that offers simple natural language input, indexed searching for fast retrieval, and a "relevance feedback" mechanism that allows the results of initial searches to influence future searches. Public domain implementations are available.

Wide Area Network (WAN)
A network, usually constructed with serial lines, which covers a large geographic area.

World Wide Web (WWW or W3)
A hypertext-based, distributed information system created by researchers at CERN in Switzerland. Users may create, edit, or browse hypertext documents. The clients and servers are freely available.

X
X is the name for TCP/IP based network-oriented window systems. Network window systems allow a program to use a display on a different computer. The most widely-implemented window system is X11, a component of MIT's Project Athena.

X.400
The CCITT and ISO standard for electronic mail. It is widely used in Europe and Canada.

X.500
The CCITT and ISO standard for electronic directory services. *See also* white pages, Knowbot, WHOIS.

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY *(leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	July 1994	Technical Memorandum

4. TITLE AND SUBTITLE
NASA Access Mechanism - Lessons Learned Document

5. FUNDING NUMBERS

6. AUTHOR(S)
Lisa Burdick, Rick Dunbar, Denise Duncan, Curtis Generous, Judy Hunter, John Lycas, Ardeth Taber-Dudas

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
NASA STI Program
Code JTT

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
National Aeronautics and Space Administration
Washington, DC 20546

10. SPONSORING / MONITORING AGENCY REPORT NUMBER
TM-109924

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION / AVAILABILITY STATEMENT
Unclassified / Unlimited
Subject category - 82

12b. DISTRIBUTION CODE

13. ABSTRACT

The six-month beta test of the NASA Access Mechanism (NAM) prototype was completed on June 30, 1993.

This report documents the lessons learned from the use of this Graphical User Interface to NASA databases such as the NASA STI Database, outside databases, Internet resources, and peers in the NASA R&D community. Design decisions, such as the use of XWindows software, a client-server distributed architecture, and use of the NASA Science Internet, are explained. Users' reactions to the interface and suggestions for design changes are reported, as are the changes made by the software developers based on new technology for information discovery and retrieval. The lessons learned section also reports reactions from the public, both at demonstrations and in response to articles in the trade press and journals.

Recommendations are included for future versions, such as a World Wide Web (WWW) and Mosaic based interface to heterogeneous databases, and NAM-Lite, a version which allows customization to include utilities provided locally at NASA Centers.

14. SUBJECT TERMS	15. NUMBER OF PAGES
databases, computer programs, information systems, prototypes, on-line systems, architecture (computers), information retrieval	37
	16. PRICE CODE A03

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	Unlimited

Available from NASA Center for AeroSpace Information
800 Elkridge Landing Road
Linthicum Heights, MD 21090-2934
(301) 621-0390